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Long-Pulsed Alexandrite Laser-Assisted Hair Removal at 5, 10, and 20 Millisecond Pulse Durations

Christopher A. Nanni, MD and Tina S. Alster, MD*

Washington Institute of Dermatologic Laser Surgery, Washington, D.C. 20037

Background: **Several laser systems with varying wavelengths, pulse durations, and energy fluences are currently utilized for hair removal. However, the ideal laser parameters and treatment candidates for photoepilation remain largely unknown. The medical literature lacks a wealth of experimental data to sufficiently document the long-term safety and efficacy of laser-assisted hair removal. This study examines the clinical efficacy and side effect profile of long-pulsed alexandrite laser-assisted hair removal utilizing laser pulse durations of either 5, 10, or 20 milliseconds (ms).**

Study Design/Methods: **Laser-assisted hair removal was performed on 36 subjects with a long-pulsed alexandrite laser. Areas of unwanted hair growth on the face, back, and legs were divided linearly into four 1 cm^2 or 2 cm^2 quadrants. Experimental regions included a control quadrant and three additional quadrants, which were treated with the alexandrite laser using an average fluence of 18 J/cm^2, with a 10 mm spot size at either a 5, 10, or 20 ms pulse duration. Hair counts and photographs were obtained before treatment, immediately following irradiation, 1 week and 1, 3, and 6 months postoperatively.**

Results: **All laser-treated quadrants displayed a significant delay in hair regrowth compared to control nontreated quadrants at postoperative week 1 and months 1 and 3. Hair counts were reduced by 66% at 1 month, 27% at 3 months, and 4% at 6 months. No significant differences in clinical efficacy or side effect profiles were observed between treatment quadrants, yet a trend towards less post-treatment erythema and hyperpigmentation was noted with the 20 ms pulse duration.**

Conclusions: **Equivalent long-term hair removal for up to 6 months was achieved with the long-pulsed alexandrite laser at 5, 10, and 20 ms pulse durations at an average fluence of 18 J/cm^2. Side effects were limited and transient. Lasers Surg. Med. 24:332–337, 1999.** **© 1999 Wiley-Liss, Inc.**

Key words: hair; alexandrite; laser; epilation; long pulse

INTRODUCTION

The removal of unwanted hair by using pulsed laser irradiation has revolutionized the hair removal industry, with over a dozen different laser systems and light sources currently available [1–3]. Although each of these photoepilation systems targets melanin with wavelengths in the red and near infrared regions of the electromagnetic spectrum, they generate varying pulse durations, spot sizes, and energy densities that provide unique clinical responses. The use of red and infrared wavelengths and millisecond (ms) pulse durations permits controlled heating of the targeted hair follicles through selective follicular thermal injury. Endogenous pigment in the hair

*Correspondence to: Tina S. Alster, 2311 M Street, N.W., Suite 200, Washington, D.C. 20037.

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TABLE 1. Patient Characteristics

Treatment area	# Patients	Gender	Skin phototype	Hair color
Upper lip	4	4 F	4 Type I	3 Brown/black 1 Blonde
Back	7	6 M 1 F	4 Type I 3 Type II	1 Blonde 2 Gray 4 Brown/black
Legs	25	23 F 3 M	10 Type I 11 Type II 4 Type III	2 Gray 23 Brown/black

follicle is necessary for this selective photoepilation process to occur. Thus, when blonde or gray hairs are being treated, an exogenous chromophore (e.g. carbon-containing solution) typically needs to be applied.

The first photoepilation system to be FDA approved for clinical use was a low energy, Q-switched (QS) Nd:YAG laser, which required pretreatment wax epilation and topical carbon solution application (SoftLight, Thermolase Corporation, La Jolla, CA). Although this patented process was a rapid and safe method for hair removal, its ability to delay hair growth was limited to no more than a few months, presumably due to its inability to adequately heat the follicular unit with its nanosecond (ns) pulse duration [4–6].

The next laser to be approved and used for epilation was a ruby laser with a 694 nm wavelength and a long 3 ms pulse duration (EpiLaser, Palomar/Coherent, Palo Alto, CA). The long-pulse ruby laser has been shown to provide long-term hair removal and, in some cases, even permanent hair removal after a single treatment with the use of high fluences [7–9].

The alexandrite laser at 755 nm (LPIR, Cynosure, Chelmsford, MA) was the third FDA-approved hair removal laser system. This system can be operated at varying pulse durations (5, 10, or 20 ms) and can produce tissue fluences of up to 40 J/cm^2. Like the ruby laser system, the 755 nm alexandrite wavelength makes the laser well-suited for hair removal as it penetrates deeply into the dermis, is absorbed by melanin within hair follicles, and has a relatively low affinity for oxyhemoglobin [10]. In addition, the adjustable pulse duration of up to 20 ms has the theoretical advantage of allowing higher fluences to be used on darker skin types with less risk of epidermal injury.

It is with these laser-tissue interactions in mind that the current study was designed. Determination of the optimal pulse duration for effective hair removal using the 755 nm long-pulsed alexandrite laser system was attempted.

MATERIALS AND METHODS

Thirty-six patients (9 M, 27 F, age range: 18–68 years, average: 31 years) were enrolled in this IRB-approved study after informed consent had been obtained. Criteria for study inclusion were patients with terminal hair growth on the upper lip, back, or lower extremities, Fitzpatrick skin phototypes I–V, and over 18 years of age. Exclusion criteria included patients with a history of photosensitivity, collagen vascular disease, seizure disorder triggered by light, concurrent pregnancy, oral retinoid use within 6 months of study entry, recently tanned skin, and very dark skin phototypes (VI).

A total of 36 anatomic locations (4 upper lip, 7 back, 25 legs) were identified for treatment. Hair colors represented included brown/black (32 subjects), gray (4), and blonde (2) (Table 1). Patients were instructed not to shave or otherwise remove hair from the treatment area for at least 1 week prior to treatment. No special preoperative topical skin lightening agents or other skin care products were prescribed nor were pretreatment topical or systemic analgesics used.

Areas of unwanted hair growth were identified and marked with a red ink pen into 1 × 4 cm facial regions and 2 × 8 cm body regions. These regions were then divided equally into four linearly arranged 1 × 1 cm or 2 × 2 cm quadrants using a predesigned template. Hair-bearing quadrants were trimmed or shaved in order to achieve a hair shaft length no greater than 1 mm above the skin surface. A clear plastic template was used to trace the treatment regions as well as to identify any significant cutaneous landmarks such as scars or nevi, which could be used to align the treatment grid for follow-up evaluations and hair counts. A thin film of a refrigerated

TABLE 2. Percent Hair Regrowth

Evaluation time	N	Control	5 ms	10 ms	20 ms
Baseline	36	100 +/– 1.1 (range, 96.5–105.3)	106.3 +/– 5.5 (range, 91.4–118)	104.8 +/– 6.8 (range, 88.7–120.3)	101.3 +/– 7.2 (range, 81.2–128.4)
1 week	36	102 +/– 5.5 (range, 93.3–122)	14.8 +/– 21.7 (range, 0–99.9) $p < .01$	13.6 +/– 21.9 (range, 0–92.9) $p < .01$	17.5 +/– 24.2 (range, 0–95.8) $p < .01$
1 month	36	106.3 +/– 20.22 (range, 80–202.7)	29.4 +/– 22 (range, 0–94.1) $p < .01$	33 +/– 24.9 (range, 0–94.3) $p < .01$	40 +/– 29.6 (range, 0–108.3) $p < .01$
3 months	36	106.8 +/– 17.4 (range, 80–180)	69.1 +/– 37.9 (range, 3.6–136.7) $p < .01$	72.7 +/– 30.2 (range, 11.6–125) $p < .01$	76.8 +/– 34.4 (range, 14.6–142.3) $p < .01$
6 months	36	100.8 +/– 7.2 (range, 88–120)	95.8 +/– 8.6 (range, 76–107.1) $p = .295$	96.8 +/– 10.4 (range, 66–112.5) $p = .31$	95.5 +/– 10.6 (range, 73.3–125) $p = .295$

water-based gel (K-Y Jelly, Lever Brothers Co. New York, NY) was then applied to each of the treatment quadrants. The control quadrant was not exposed to laser irradiation. The remaining three quadrants were treated with a long-pulsed alexandrite laser (LPIR, Cynosure, Chelmsford, MA) by a single operator (CAN). Fluences of 15–20 J/cm^2 were delivered through a flexible handpiece using adjacent nonoverlapping 10 mm laser spots. Exposed hair shafts were completely vaporized upon laser impact with evidence of residual shaft remnants in the follicle. An immediate erythematous skin response was observed in the laser-irradiated sites.

Patients were given a take-home diary and were instructed to document any adverse reactions. Gentle cleansing with mild soap (e.g., Dove, Johnson & Johnson Medical, Inc., Arlington, TX), sun avoidance, and discontinuation of any irritating skin care products (e.g., acne medications) was advised. Patients returned for follow-up photographs and manual hair counts in the treatment grids 1 week and 1, 3, and 6 months postoperatively. Percent of hair regrowth was determined by dividing the amount of new hair growth at each visit by the original hair count for each respective quadrant. The same technician blinded to the study treatment parameters performed manual hair counts in all subjects at each follow-up visit. The average of three manual counts was calculated and recorded for each quadrant.

RESULTS

All laser-treated quadrants displayed a significant delay in hair regrowth compared to control quadrants at 1 week and months 1 and 3 (Table 2). No significant differences were seen in hair regrowth rates between the use of 5 ms, 10 ms, and 20 ms pulse durations. An average of 66% hair reduction was recorded at the 1 month follow-up, 27% average hair reduction was observed at the 3 month follow-up, and only a 4% hair decrease remained at the 6 month follow-up visit (Figs. 1–3). Although on average there was no significant reduction in hair growth by the 6 month follow-up, three individual subjects did experience a cosmetically visible reduction in hair density (hair reductions of 11%, 20%, and 18%). These subjects had Fitzpatrick skin phototypes III, brown hair, and received treatment to their lower extremities.

Complications were limited to immediate posttreatment erythema in 97% of patients, minimal intraoperative treatment pain in 85%, transient hyperpigmentation in 3%, and mild blistering in less than 1% (one case). Although hyperpigmentation was observed at all pulse durations in certain individuals, it was generally of less severity and resolved more rapidly in the 20 ms pulse duration quadrants. Average duration of hyperpigmentation was 6 weeks. Intraoperative treatment pain was rated equivalent by patients in all laser-irradiated quadrants; however, more "burning" was reported at 20 ms.

DISCUSSION

Laser-assisted hair removal using a long-pulsed 755 nm alexandrite laser is an effective and safe method to delay hair regrowth for up to 6 months. Significant hair removal and an equivalent delay in hair regrowth is observed when using either a 5, 10, or 20 ms pulse duration at an average fluence of 18 J/cm^2.

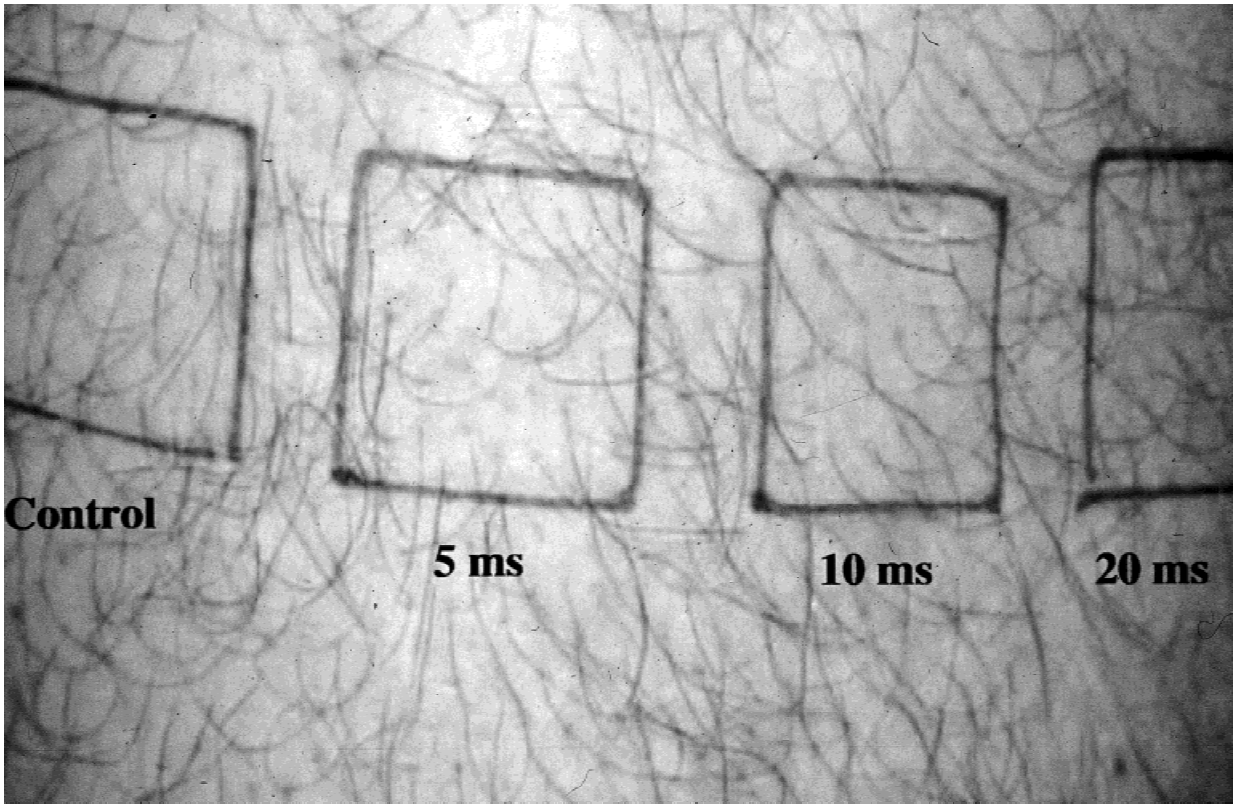

Fig. 1. Study quadrants on the leg prior to laser treatment (baseline).

The fact that all pulse durations resulted in equivalent hair removal may be a result of the small sample size studied or may be due to the fact that hair removal is similarly effective when using millisecond pulse durations (in contrast to the relative ineffectivity at nanosecond pulse durations). Theoretically, a 20 ms pulse duration should be less traumatic to epidermal melanosomes than would shorter pulse durations because the small cutaneous targets are more severely damaged by short (ns) pulses. Larger cutaneous structures such as hair follicles, however, sustain greater injury at longer pulse durations because there is time for the laser energy to be absorbed. This enhanced selectivity of the longer 20 ms pulse duration was best observed in the study subjects who exhibited very mild posttreatment erythema and hyperpigmentation.

Based upon cumulative clinical experience and more recent reports in the literature regarding "permanent" epilation after a single laser treatment, higher fluences (up to 40 J/cm^2) are often necessary to achieve long-term hair reduction [9]. As such, the fluences used in this study were conservative and may have led to a reduced rate of effectiveness. Therefore, further study of the alexandrite laser system at higher energy densities is needed to determine its maximum potential efficacy.

As would be expected, blonde and gray hairs did not respond as well to alexandrite laser treatment as did brown or black hair because of the reduced melanin content of the follicles and/or shafts in these hair types. Similar pigment-dependent efficacy has been reported with other laser hair removal systems. It is unclear whether the use of higher fluences or additional laser sessions might be more successful in treating lighter hair colors (in an attempt to provide even a small thermal effect on the follicular unit).

In general, subjects at the 6 month follow-up did not have significant hair count reduction when compared to control quadrants or baseline hair counts. At least three subjects, however, did have significant hair density reduction that was clinically evident. The fact that these three patients had brown hair, skin phototype III, and lower extremity involvement may suggest a particularly susceptible treatment group or it may indicate that some individuals respond uniquely better to photoepilation than others.

This study lends support to conclusions

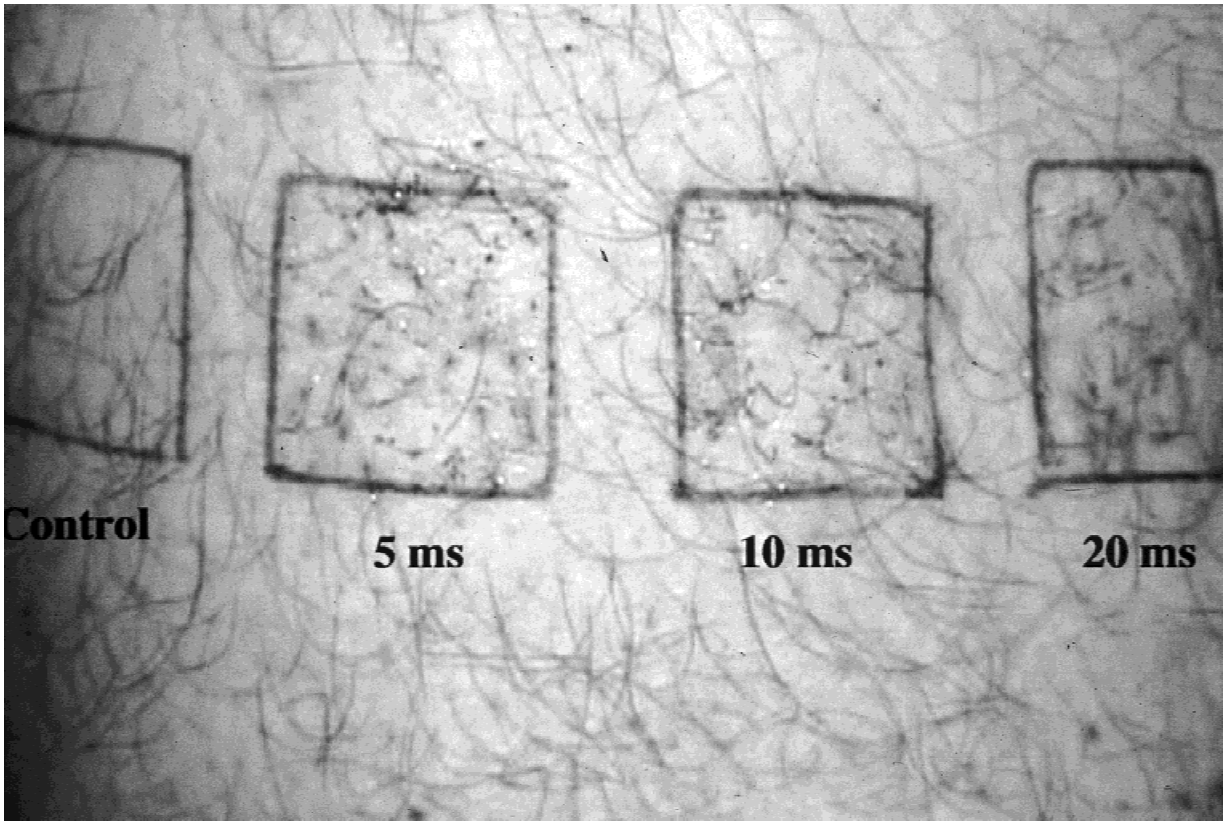

Fig. 2. Same study quadrants on the leg immediately after long-pulsed alexandrite laser irradiation (20 J/cm^2).

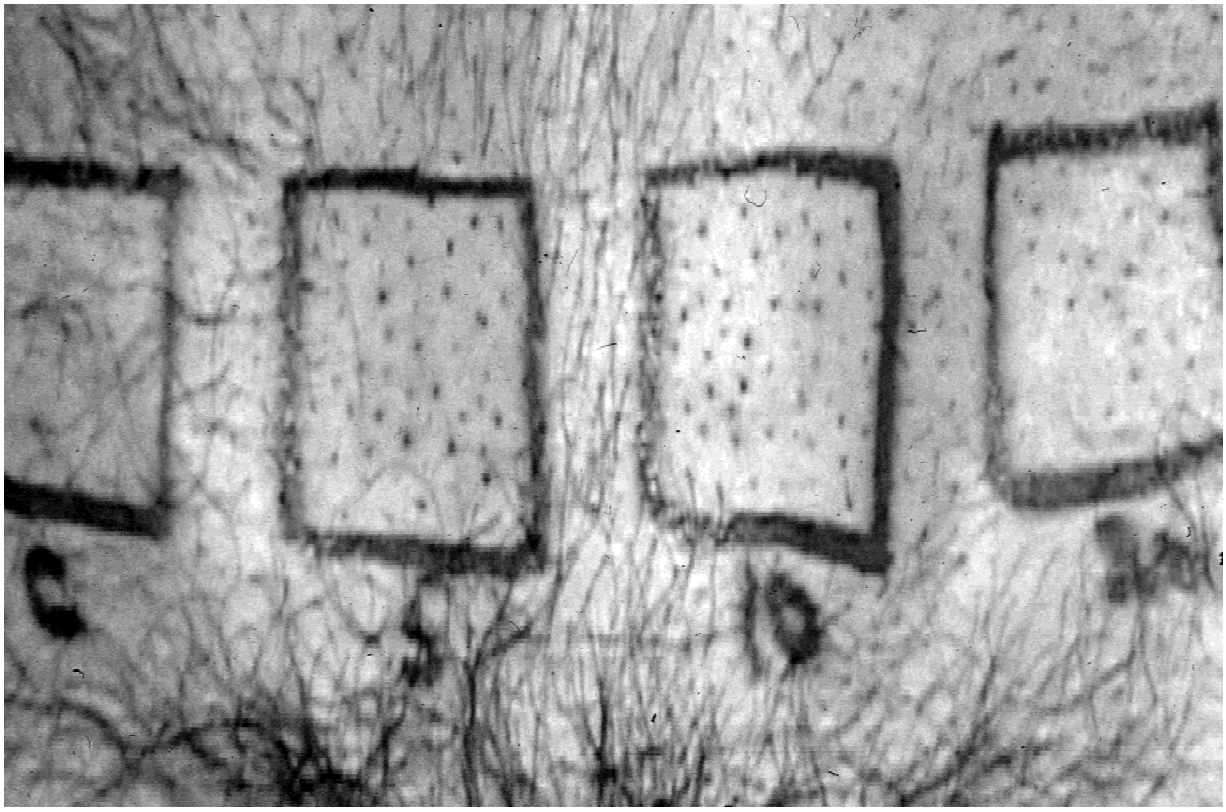

Fig. 3. Study quadrants on the leg 1 month following long-pulsed alexandrite laser treatment. Note minimal hair regrowth in all laser-irradiated quadrants, regardless of 5, 10, or 20 ms pulse duration.

drawn from other reports suggesting that multiple successive laser treatments are necessary in order to attain significant long-term epilation [1,2,4]. Complications were limited in severity and duration after long-pulsed alexandrite laser irradiation at any of the pulse durations under study and were observed only in subjects with darker skin tones (phototypes III–V).

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